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COMBINING BIASED RANDOMIZATION WITH META-HEURISTICS FOR SOLVING THE MULTI-DEPOT VEHICLE ROUTING PROBLEM

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ABSTRACT

This paper proposes a hybrid algorithm, combining Biased-Randomized (BR) processes with an Iterated Local Search (ILS) meta-heuristic, to solve the Multi-Depot Vehicle Routing Problem (MDVRP). Our approach assumes a scenario in which each depot has unlimited service capacity and in which all vehicles are identical (homogeneous fleet). During the routing process, however, each vehicle is assumed to have a limited capacity. Two BR processes are employed at different stages of the ILS procedure in order to: (a) define the perturbation operator, which generates new 'assignment maps' by associating customers to depots in a biased-random way –according to a distance-based criterion; and (b) generate 'good' routing solutions for each customers-depots assignment map. These biased-randomization processes rely on the use of a pseudo-geometric probability distribution. Our approach does not need from fine-tuning processes which usually are complex and time consuming. Some preliminary tests have been carried out already with encouraging results.

The Capacitated Vehicle Routing Problem (CVRP) is probably the most popular routing problem in the literature on combinatorial optimization. The basic goal here is to find an 'optimal' set of routes for a fleet of vehicles so that a set of customers' demands are satisfied. Usually all vehicles are considered to be identical (homogeneous fleet). All routes begin and end at one or several depots, where all resources are initially located. Typically each vehicle has a maximum loading capacity, each customer is supplied by a single vehicle, and a vehicle cannot stop twice at the same customer. Therefore, the objective function to optimize as well as the associated constraints include costs related to distances traveled by vehicles and/or to times employed during the distribution process.

Different approaches to the CVRP have been explored during the last decades, ranging from the use of pure optimization methods such as linear programming –mainly used for solving small- to medium-size problems with relatively simple constraints–, to the use of heuristics and meta-heuristics that provide near-optimal solutions for medium and large-size problems with more complex constraints **(Laporte 2007)**. One of the less studied variant in the literature is the so-called Multi-Depot Vehicle Routing Prob-

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lem (MDVRP). This is a challenging problem since it integrates a combinatorial assignment problem – which customers are to be assigned to each depot– with the several CVRPs that must be solved for each customers-depot assignment. Of course, assignment and routing problems are interrelated and thus it is not trivial to find the customers-depots assignments which will provide the optimal routing solution for the entire set of customers and depots.

Accordingly, this paper builds upon some of our previous works and proposes a hybrid approach which combines the SR-GCWS-CS simulation-based algorithm **(Juan et al. 2011b)** with an Iterated Local Search (ILS) metaheuristic **(Lourenço et al. 2010)** to deal with the MDVRP. To the best of our knowledge, it is the first time a Biased-Randomized (BR) algorithm is used to efficiently solve the multi-depot version of the VRP. Moreover, being a parameter-less algorithm, it represents an interesting alternative to other state-of-the-art metaheuristics, which are usually harder to implement in practice and which often require from much more complex and time-costly fine-tuning processes.

One of the innovative aspects of the approach we present in this paper is that it combines Monte Carlo Simulation (MCS) techniques with a powerful metaheuristic framework in order to solve a challenging combinatorial optimization problem. Roughly speaking, MCS can be defined as a set of techniques that make use of random numbers and statistical distributions to solve certain stochastic and deterministic problems **(Law 2007)**. When properly combined with heuristic techniques, MCS has proved to be extremely useful for solving stochastic vehicle routing problems **(Juan et al. 2011a)**. But even when solving deterministic routing problems, approaches combining biased-randomization with heuristics can be efficiently used for solving the CVRP. In particular, the SR-GCWS-CS algorithm proposed by **Juan et al. (2011b)**, makes use of a pseudo-geometric distribution to induce a Biased Randomization (BR) process into the Clarke and Wright Savings heuristic **(Clarke and Wright 1964)**. By doing so, a new feasible and probably 'good' solution is obtained each time the biased-randomized version of the CWS is executed. Then, just by iterating this fast constructive process, a set of different feasible solutions are generated. Each of these feasible solutions will consist of a set of roundtrip routes from the depot that, altogether, satisfy all problem constraints and node demands.

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